

in a "slanting manner" such that virtual line segments of the linear elastic members 102C and 102D extending in the longitudinal direction intersect with each other at a single point.

5 [0013] In this case, when the lens holder 101 turns with respect to the center O of the base 100 by the angle θ , tensile forces are respectively generated in the linear elastic members 102A and 102C which are opposed to each other across the center O, and compressive forces are respectively generated in the linear elastic members 102B and 102D which are opposed to each other across the center O. Therefore, a relative displacement in the axial direction occurs, which increases the rolling frequency.

10 In this case as well, no damping effect is achieved and oscillation continues.

[0014] In the respective conventional examples as described above, in addition to a problem of a deterioration in damping characteristics, there is also a problem in that considerable mounting accuracy in a production process is required and that deformation is generated due to changes in temperature caused by a difference in coefficients of linear expansion between a material of the linear elastic members (i.e., metal) and a material of
15 the base and the lens holder (i.e., synthetic resin).

[0015] It is an object of the present invention to provide an actuator for a pickup which makes it possible to suppress a rise in rolling frequency and to prevent deterioration in damping characteristics even when a movable portion is turned with respect to a fixed
20 portion, a pickup device, a recording medium drive device, and a method of producing an actuator for a pickup.

Means for solving the Problems

[0016] According to an aspect of the present invention, an actuator for a pickup includes:
25 a fixed portion; a movable portion movable in each of a focusing direction extending along an optical axis of an objective lens and in a tracking direction substantially perpendicular to the focusing direction, for holding the objective lens; and a plurality of linear elastic members of five or more each having ends connected to the movable portion and the fixed portion, respectively. The linear elastic members that are adjacent to each

other when viewed from the focusing direction are designed such that a dimension between connection portions of the linear elastic members connected to the fixed portion is larger than a dimension between connection portions of the linear elastic members connected to the movable portion. The plurality of linear elastic members have

5 connection portions on a side of the fixed portion which are located on a first virtual circle and connection portions on a side of the movable portion which are located on a second virtual circle.

~~Here, the first virtual circle and the second virtual circle may or may not coincide with each other. The first virtual circle and the second virtual circle coincide with each other when the plurality of linear elastic members extend in parallel to one another.~~

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[0017] According to another aspect of the present invention, an actuator for a pickup includes: a fixed portion; a movable portion movable in each of a focusing direction extending along an optical axis of an objective lens and in a tracking direction substantially perpendicular to the focusing direction, for holding the objective lens; and a

15 plurality of linear elastic members of four or more each having ends connected to the movable portion and the fixed portion, respectively. The linear elastic members that are adjacent to each other when viewed from the focusing direction are designed such that a dimension between connection portions of the linear elastic members connected to the fixed portion is different from a dimension between connection portions of the linear

20 elastic members connected to the movable portion. The linear elastic members that are adjacent to each other when viewed from the tracking direction are designed such that a dimension between connection portions of the linear elastic members connected to the fixed portion is different from a dimension between connection portions of the linear elastic members connected to the movable portion. The connection portions of the

25 plurality of linear elastic members on a side of the fixed portion are located on a first virtual circle. The connection portions of the plurality of linear elastic members on a side of the movable portion are located on a second virtual circle that is different from the first virtual circle. The two virtual circles have a virtual center line connecting centers thereof to each other, the virtual center line intersecting at a single point with virtual

extended lines extending on the side of the movable portion in a longitudinal direction of the plurality of linear elastic members.

[0018] A pickup device according to still another aspect of the present invention includes the actuator for a pickup of the present invention and an actuator drive portion for driving the actuator for a pickup.

[0019] A recording medium drive device according to yet another aspect of the present invention includes the pickup device according to the present invention.

[0020] According to further aspect of the present invention, a method of producing an actuator for a pickup including a fixed portion, a movable portion movable in each of a focusing direction extending along an optical axis of an objective lens and in a tracking direction substantially perpendicular to the focusing direction, for holding the objective lens, and a plurality of linear elastic members of five or more each having ends connected to the movable portion and the fixed portion, respectively includes the steps of: disposing the linear elastic members that are adjacent to each other when viewed from the focusing direction such that a dimension between connection portions of the linear elastic members connected to the fixed portion is larger than a dimension between connection portions of the linear elastic members connected to the movable portion, in connecting the plurality of linear elastic members to the fixed portion and the movable portion; locating connection portions of the plurality of linear elastic members on a side of the fixed portion on a first virtual circle; and locating connection portions of the plurality of linear elastic members on a side of the movable portion on a second virtual circle.

[0021] Further, according to still further aspect of the present invention, a method of producing an actuator for a pickup including a fixed portion, a movable portion movable in each of a focusing direction extending along an optical axis of an objective lens and in a tracking direction substantially perpendicular to the focusing direction, for holding the objective lens, and a plurality of linear elastic members of four or more each having ends connected to the movable portion and the fixed portion, respectively includes the steps of: disposing the linear elastic members that are adjacent to each other when viewed from the focusing direction such that a dimension between connection portions of the linear elastic

members connected to the fixed portion is different from a dimension between connection portions of the linear elastic members connected to the movable portion, in connecting the plurality of linear elastic members to the fixed portion and the movable portion; disposing the linear elastic members are adjacent to each other when viewed from the tracking

5 direction such that a dimension between connection portions of the linear elastic members connected to the fixed portion is different from a dimension between connection portions of the linear elastic members connected to the movable portion, in connecting the plurality of linear elastic members to the fixed portion and the movable portion; locating the connection portions of the plurality of linear elastic members on a side of the fixed portion

10 on a first virtual circle; locating the connection portions of the plurality of linear elastic members on a side of the movable portion on a second virtual circle that is different from the first virtual circle; and disposing the plurality of linear elastic members such that a virtual center line connecting centers of the two virtual circles to each other intersects at a single point with virtual extended lines extending on the side of the movable portion in a

15 longitudinal direction of the plurality of linear elastic members.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] [Fig. 1A] A schematic diagram showing a state in which six linear elastic members are arranged in a conventional art as viewed in a direction from a lens holder to a

20 base.

[Fig. 1B] A schematic diagram showing a state in which four linear elastic members are arranged in another conventional art as viewed in a direction from a lens holder to a base.

[Fig. 2] A perspective view showing an entire pickup device according to

25 Embodiment 1 of the present invention.

[Fig. 3] A plan view showing the entire pickup device according to the Embodiment 1 of the present invention.

[Fig. 4A] A schematic diagram showing a mounting structure of suspensions according to the Embodiment 1 of the present invention as viewed from a tracking

CLAIMS

[1] (Amended) _____ An actuator for a pickup, comprising:

a fixed portion;

5 a movable portion movable in each of a focusing direction extending along an optical axis of an objective lens and in a tracking direction substantially perpendicular to the focusing direction, for holding the objective lens; and

a plurality of linear elastic members of five or more each having ends connected to the movable portion and the fixed portion, respectively, wherein

10 wherein the linear elastic members that are adjacent to each other when viewed from the focusing direction are designed such that a dimension between connection portions of the linear elastic members connected to the fixed portion is larger than a dimension between connection portions of the linear elastic members connected to the movable portion, and

_____ the plurality of linear elastic members have connection portions on a side of the
15 fixed portion which are located on a first virtual circle, and connection portions on a side of the movable portion which are located on a second virtual circle.

[2] (Deleted) ~~The actuator for the pickup according to Claim 1, wherein the plurality of linear elastic members extend in parallel to one another.~~

[3] (Amended) _____ The actuator for the pickup according to Claim 1, wherein:

20 ~~_____ the linear elastic members that are adjacent to each other when viewed from the focusing direction are designed such that a dimension between the connection portions connected to the fixed portion is different from a dimension between the connection portions connected to the movable portion; and~~

_____ the linear elastic members that are adjacent to each other when viewed from the
25 tracking direction are designed such that a dimension between the connection portions connected to the fixed portion is ~~different from~~ larger than a dimension between the connection portions connected to the movable portion.

[4] The actuator for a pickup according to any one of Claims 1 to 3, further comprising six of the linear elastic members.

[5] (Amended) An actuator for a pickup, comprising:

a fixed portion;

a movable portion movable in each of a focusing direction extending along an optical axis of an objective lens and in a tracking direction substantially perpendicular to the focusing direction, for holding the objective lens; and

a plurality of linear elastic members of four or more each having ends connected to the movable portion and the fixed portion, respectively, wherein:

the linear elastic members that are adjacent to each other when viewed from the focusing direction are designed such that a dimension between connection portions of the linear elastic members connected to the fixed portion is different from a dimension between connection portions of the linear elastic members connected to the movable portion;

the linear elastic members that are adjacent to each other when viewed from the tracking direction are designed such that a dimension between connection portions of the linear elastic members connected to the fixed portion is different from a dimension between connection portions of the linear elastic members connected to the movable portion;

the connection portions of the plurality of linear elastic members on a side of the fixed portion are located on a first virtual circle;

the connection portions of the plurality of linear elastic members on a side of the movable portion are located on a second virtual circle that is different from the first virtual circle; and

the two virtual circles have a virtual center line connecting centers thereof to each other, the virtual center line intersecting at a single point with virtual extended lines extending on the side of the moveable portion in a longitudinal direction of the plurality of linear elastic members.

[6] The actuator for the pickup according to Claim 5, further comprising four of the linear elastic members.

[7] A pickup device, comprising the actuator for the pickup according to any one of

Claims 1 to 6 and an actuator drive portion for driving the actuator for a pickup.

[8] (Amended) A recording medium drive device, comprising the pickup device according to Claim 5.

- [9] (Deleted) A method of producing an actuator for a pickup comprising a fixed portion, a movable portion movable in each of a focusing direction extending along an optical axis of an objective lens and in a tracking direction substantially perpendicular to the focusing direction, for holding the objective lens, and a plurality of linear elastic members of five or more each having ends connected to the movable portion and the fixed portion, respectively,
- 10 the method comprising the steps of:
- the method comprising the steps of:
 - locating connection portions of the plurality of linear elastic members on a side of the fixed portion on a first virtual circle; and
 - locating connection portions of the plurality of linear elastic members on a side of the movable portion on a second virtual circle.
- 15 [10] (Deleted) A method of producing an actuator for a pickup comprising a fixed portion, a movable portion movable in each of a focusing direction extending along an optical axis of an objective lens and in a tracking direction substantially perpendicular to the focusing direction, for holding the objective lens, and a plurality of linear elastic members of four or more each having ends connected to the movable portion and the fixed
- 20 portion, respectively,
- the method comprising the steps of:
 - disposing the linear elastic members that are adjacent to each other when viewed from the focusing direction such that a dimension between connection portions of the linear elastic members connected to the fixed portion is different from a dimension
 - 25 between connection portions of the linear elastic members connected to the movable portion, in connecting the plurality of linear elastic members to the fixed portion and the movable portion;
 - disposing the linear elastic members that are adjacent to each other when viewed from the tracking direction such that a dimension between connection portions of the

~~linear elastic members connected to the fixed portion is different from a dimension between connection portions of the linear elastic members connected to the movable portion, in connecting the plurality of linear elastic members to the fixed portion and the movable portion;~~

5 ~~——— locating the connection portions of the plurality of linear elastic members on a side of the fixed portion on a first virtual circle;~~

~~——— locating the connection portions of the plurality of linear elastic members on a side of the movable portion on a second virtual circle that is different from the first virtual circle; and~~

10 ~~——— disposing the plurality of linear elastic members such that a virtual center line connecting centers of the two virtual circles to each other intersects at a single point with virtual extended lines extending in a longitudinal direction of the plurality of linear elastic members.~~

[11] ~~(Deleted) The method of producing the actuator for the pickup according to Claim~~
15 ~~9 or 10, further comprising the steps of:~~

~~——— installing the linear elastic members in a mold for molding the fixed portion and the movable portion; and~~

~~——— injecting a molten resin from an injection port of the mold to insert mold the actuator for a pickup.~~

20 [12] (Added) A method of producing an actuator for a pickup comprising a fixed portion, a movable portion movable in each of a focusing direction extending along an optical axis of an objective lens and in a tracking direction substantially perpendicular to the focusing direction, for holding the objective lens, and a plurality of linear elastic members of five or more each having ends connected to the movable portion and the fixed
25 portion, respectively,

——— the method comprising the steps of:

——— disposing the linear elastic members that are adjacent to each other when viewed from the focusing direction such that a dimension between connection portions of the linear elastic members connected to the fixed portion is larger than a dimension between

connection portions of the linear elastic members connected to the movable portion, in connecting the plurality of linear elastic members to the fixed portion and the movable portion;

_____ locating connection portions of the plurality of linear elastic members on a side of
 5 the fixed portion on a first virtual circle; and

_____ locating connection portions of the plurality of linear elastic members on a side of
the movable portion on a second virtual circle.

[13] _____ (Added) The method of producing the actuator for the pickup according to Claim
12, further comprising the steps of:

10 _____ disposing the linear elastic members that are adjacent to each other when viewed
from the tracking direction are disposed such that a dimension between connection
portions of the linear elastic members connected to the fixed portion is larger than a
dimension between connection portions of the linear elastic members connected to the
movable portion, in connecting the plurality of linear elastic members to the fixed portion
 15 and the movable portion.

[14] _____ (Added) A method of producing an actuator for a pickup comprising a fixed
portion, a movable portion movable in each of a focusing direction extending along an
optical axis of an objective lens and in a tracking direction substantially perpendicular to
the focusing direction, for holding the objective lens, and a plurality of linear elastic
 20 members of four or more each having ends connected to the movable portion and the fixed
portion, respectively,

_____ the method comprising the steps of:

_____ in connecting the plurality of linear elastic members to the fixed portion and the
movable portion, disposing the linear elastic members that are adjacent to each other when
 25 viewed from the focusing direction such that a dimension between connection portions of
the linear elastic members connected to the fixed portion is different from a dimension
between connection portions of the linear elastic members connected to the movable
portion;

_____ disposing the linear elastic members that are adjacent to each other when viewed

from the tracking direction such that a dimension between connection portions of the linear elastic members connected to the fixed portion is different from a dimension between connection portions of the linear elastic members connected to the movable portion;

5 _____ locating the connection portions of the plurality of linear elastic members on a side of the fixed portion on a first virtual circle;

_____ locating the connection portions of the plurality of linear elastic members on a side of the movable portion on a second virtual circle that is different from the first virtual circle; and

10 _____ disposing the plurality of linear elastic members such that a virtual center line connecting centers of the two virtual circles to each other intersects at a single point with virtual extended lines extending on the side of the movable portion in a longitudinal direction of the plurality of linear elastic members.

[15] _____ (Added) The method of producing the actuator for the pickup according to Claim

15 14, further comprising the steps of:

_____ disposing the linear elastic members symmetrically about the centers of the two virtual circles.

[16] _____ (Added) The method of producing the actuator for the pickup according to any one of Claims 12 to 15, further comprising the steps of:

20 _____ installing the linear elastic members in a mold for molding the fixed portion and the movable portion; and

_____ injecting a molten resin from an injection port of the mold to insert-mold the actuator for a pickup.